AD-A187 513 OPERATORS MANUAL FOR A COMPUTER CONTROLLED IMPEDANCE MEASUREMENT SYSTEM(U) AERONAUTICAL RESEARCH LABS MELBOURNE (AUSTRALIA) J GORDON FEB 87 ARL-STRU-TM-458 1/1

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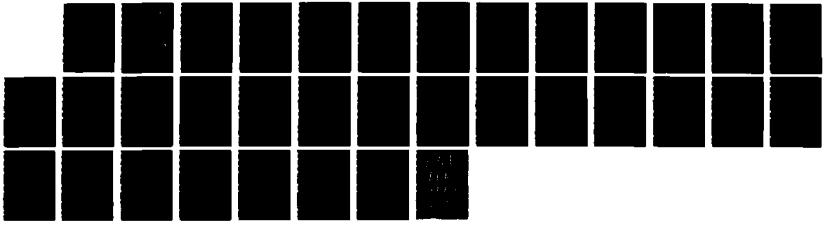

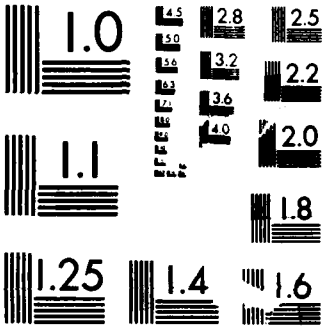

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MELBOURNE, VICTORIA

Structures Technical Memorandum 458

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OPERATORS MANUAL FOR A COMPUTER CONTROLLED IMPEDANCE MEASUREMENT SYSTEM

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SUMMARY

Operating instructions of a computer controlled impedance measurement system based on Hewlett Packard instrumentation are given. Hardware details, program listings, flowcharts and a practical application are included.

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CONTENTS

1. INTRODUCTION

In many areas of electronic design and in the evaluation of the performance of electronic equipment, the impedance of a component or network, at a single frequency, or over a range of frequencies is required to be known.

When this entails a large number of measurements, or the testing of many components, the data acquistion becomes tedious, time consuming and prone to error. An automated impedance measuring and recording system becomes an asset.

The need for the development of such a system at ARL arose when impedance measurements and analysis of six commercial ultrasonic transducers over a frequency range of 0.1MHz to 13MHz were required.

This paper descibes the hardware, software and operating procedures of an impedance measurement system that was subsequently developed.

2. INSTRUMENTATION

A block diagram of the impedance measurement system is shown in Figure 1. It consists of the following:

i. A Hewlett Packard HP86 computer, fitted with a Hewlett Packard interface bus (HPIB) adaptor,
ii. A Hewlett Packard HP82913A monitor,
iii. Two Hewlett Packard HP9130A flexible disc drives,
iv. A Hewlett Packard 82905B printer,
v. A Hewlett Packard 7470A plotter, and
vi. A Hewlett Packard 4192A low frequency(LF) impedance analyser.

2.1 Computer

The HP86 communicates with the impedance analyser via the HPIB. This enables remote control of all setup parameters, and acquistion of measured data. After processing, the data can be displayed graphically on the monitor or the plotter. The measured data can stored and retrieved from flexible disc.

2.2 Analyser

The HP4192A LF impedance analyser is a fully automatic, high performance instrument which can be used manually, or , as in this application, coupled to a computer via a HPIB interface. The HPIB interface provides complete remote control of all front panel functions of the analyser, and all measurements

are taken under software control. Once all the parameters are set up via the computer keyboard, no further interaction is required.

The impedance analyser measures parameters in pairs, and in the work reported here, the parameters are software selected. A detailed description of the parameters is given in Section 4.1. A summary of the capabilities of the analyser and brief specifications are listed in Table 1.

2.3 Test fixtures

Three types of test fixtures are provided with the analyser. The different test fixtures ,described below, facilitate the connection of a range of components.

The HP16047A, is a direct coupled fixture for measurement of axial or radial lead components. Three interchangeable contact inserts can be plugged into the fixture. The contacts are for axial lead components, general radial lead components and radial short lead components. Components connected to this fixture can have up to plus or minus 35 Volts D.C. bias applied.

The HP16048A fixture has four test leads giving four terminal pairs with BNC connectors for use with user fabricated test fixtures. The cable is one metre long and the analyser automatically compensates for transmission line phase shift effects between the measuring circuitry and the component being measured. Direct current bias up to plus or minus 200 Volts can be applied to the component under test.

The HP16095A probe fixture enables measurement of a two port component or network in a circuit, with both ports floating or one port grounded.

2.4 Hewlett Packard Interface Bus

The hardware components of the impedance measuring system are connected together by a Hewlett Packard Interface Bus (HPIB) which is compatible with the IEEE488 general purpose interface bus standard. The HPIB enables keyboard control of the printer, plotter, and impedance analyser.

3. SOFTWARE

The software is written in HP Basic as described in reference 1. The main program has calls to fourteen subroutines to measure, process, store, retrieve, display or plot data, and to modify plot size and scales. A block flowchart, shown

in Figure 2, details the processes performed by the software. A complete flowchart of the main program and listing is contained in Appendix I.

The data are stored in the same format as the analyser output data. This ensures that no information is lost, and that if the direction or emphasis of an experiment changes, or some unexpected or unusual effect is observed, then relevant information has not been discarded by data reduction. The small price paid for this added flexibility is a slight increase in processing time required when converting the data into a suitable format for plotting.

The software has been written to be flexible and to allow easy modification. The subroutines are virtually self contained and thus can be utilized alone or in other programs for plotting, storing, or retrieving data, especially with the hardware used here. The graphics routines have been written in user units, which enables plots to be scaled by simply changing the size of the numbers in the limit statement and the values of eight setup parameters. When these numbers are changed the size of the plot, and the spacing of the labels is automatically scaled so that plots can be produced to fill a standard A4 size page, or of correct size for ARL publications ,or any other size. Table 2 lists the constants to be changed for various common applications, and their locations in the program.

4. OPERATING INSTRUCTIONS

After loading and running the program "IMPSTORE ", the user is guided by program prompts to select the appropriate options. Specific instructions for measuring, plotting, storing and retrieving data are given below.

4.1 Measuring data

In this program mode, the operator must choose amongst the available options for each of the following :-

a. Electrical parameters.

The parameters being complex quantities are measured by the analyser in pairs, allowing some option for the secondary parameter. The required parameters can be selected from the list below.

PRIMARY PARAMETER	SECONDARY PARAMETER
Impedance (Z)	Phase Degrees (D) Phase Radians (R)
Admittance (Y)	Phase Degrees (D) Phase Radians (R)
Resistance (R)	Reactance (X)
Conductance (G)	Susceptance (B)
Capacitance (C)	Quality (Q) Dissipation (D) Resistance (R) Conductance (G)
Inductance (L)	Quality (Q) Dissipation (D) Resistance (R) Conductance (G)
Gain (B-A)	Delay (G) Degrees (D) Radians (R)
Ref Amp (A)	dBV (V) dBm (M)
Ref Amp (B)	dBV (V) dBm (M)

b. Resolution of data measurement.

Options are high speed (S), normal (N), and accuracy (A). Further details of the measurement accuracy and speed are given in reference 2.

c. Frequency scale.

Options are linear or logarithmic.

d. Upper and lower frequency.

e. Number of measurement steps for frequency sweep.

For logarithmic scale the upper and lower limits are rounded to the correct decade, and twenty-one measurements are made per decade.

4.2 Displaying data

Measured or stored data can be displayed on the monitor or plotted by entering the following data:-

a. Minimum and maximum values of the primary parameter Y axis. Default values are the minimum and maximum measured values.

b. Ten or six divisions for the secondary parameter Y axis when the secondary parameter is phase and the units are degrees. A six division axis is more convenient for displaying 360 degrees or commonly used parts of 360 degrees.
c. Minimum and maximum values of the secondary parameter Y axis for either ten or six divisions. Default values are the minimum and maximum measured values for ten divisions, and minus 90 degrees to 90 degrees for six divisions.
d. Monitor or hardcopy display.

4.3 Storing

For storing raw measured data on flexible disc enter a title which becomes the name of the datafile created. An optional identifier can also be stored on the data file.

4.4 Retrieving

To read stored data it is only necessary to enter the name of the datafile in which the data are stored. The optional identifier stored with the data is displayed on the monitor.

5. EXAMPLE

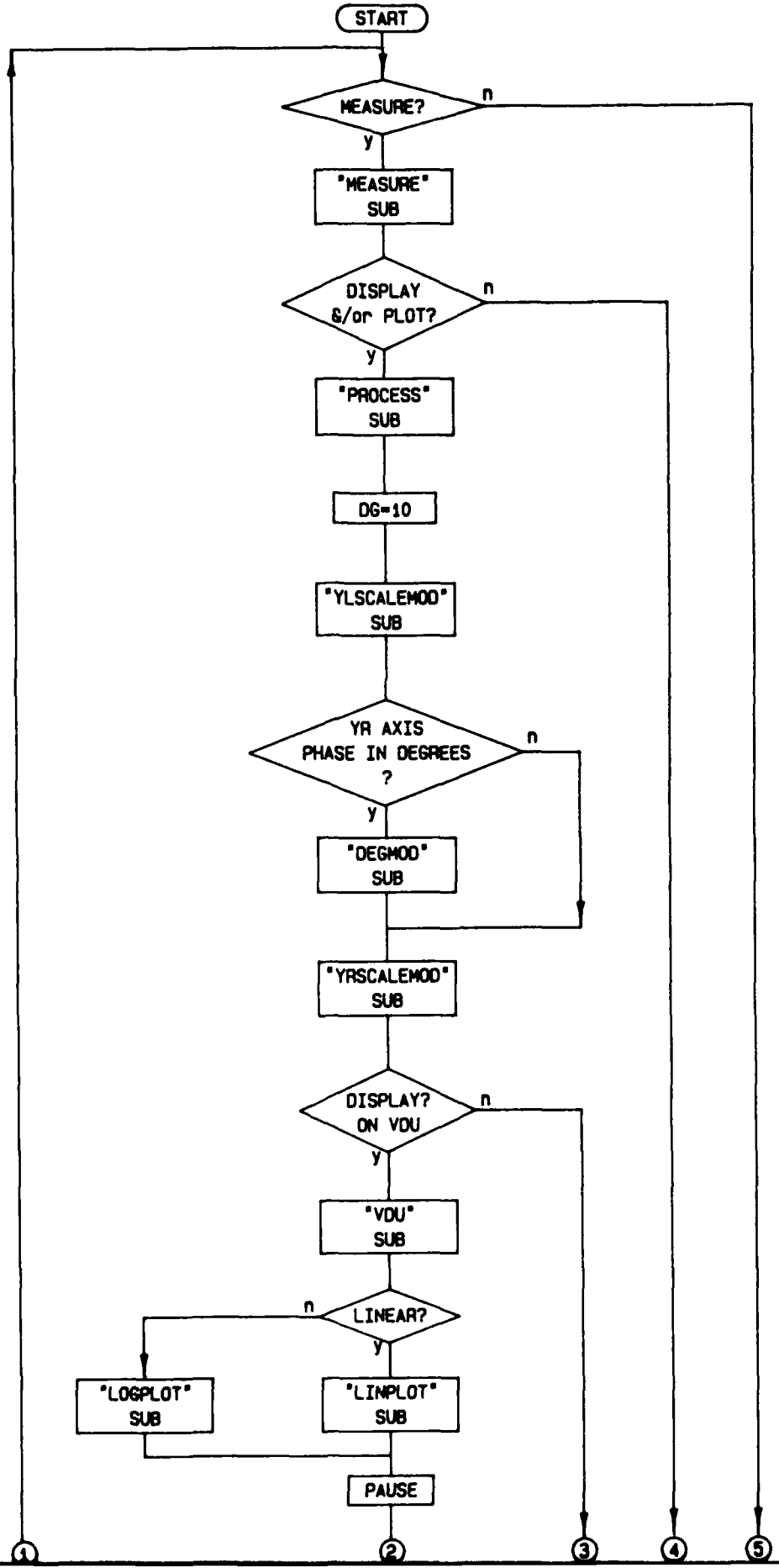
The system has been used to measure the impedance of a commercial ultrasonic transducer (Krautkramer K5K). An example of the graphical output of the program is shown in Figure 3. A detailed listing of the setup procedure, the operator responses and scale modification procedure used to obtain this output is given in Appendix II.

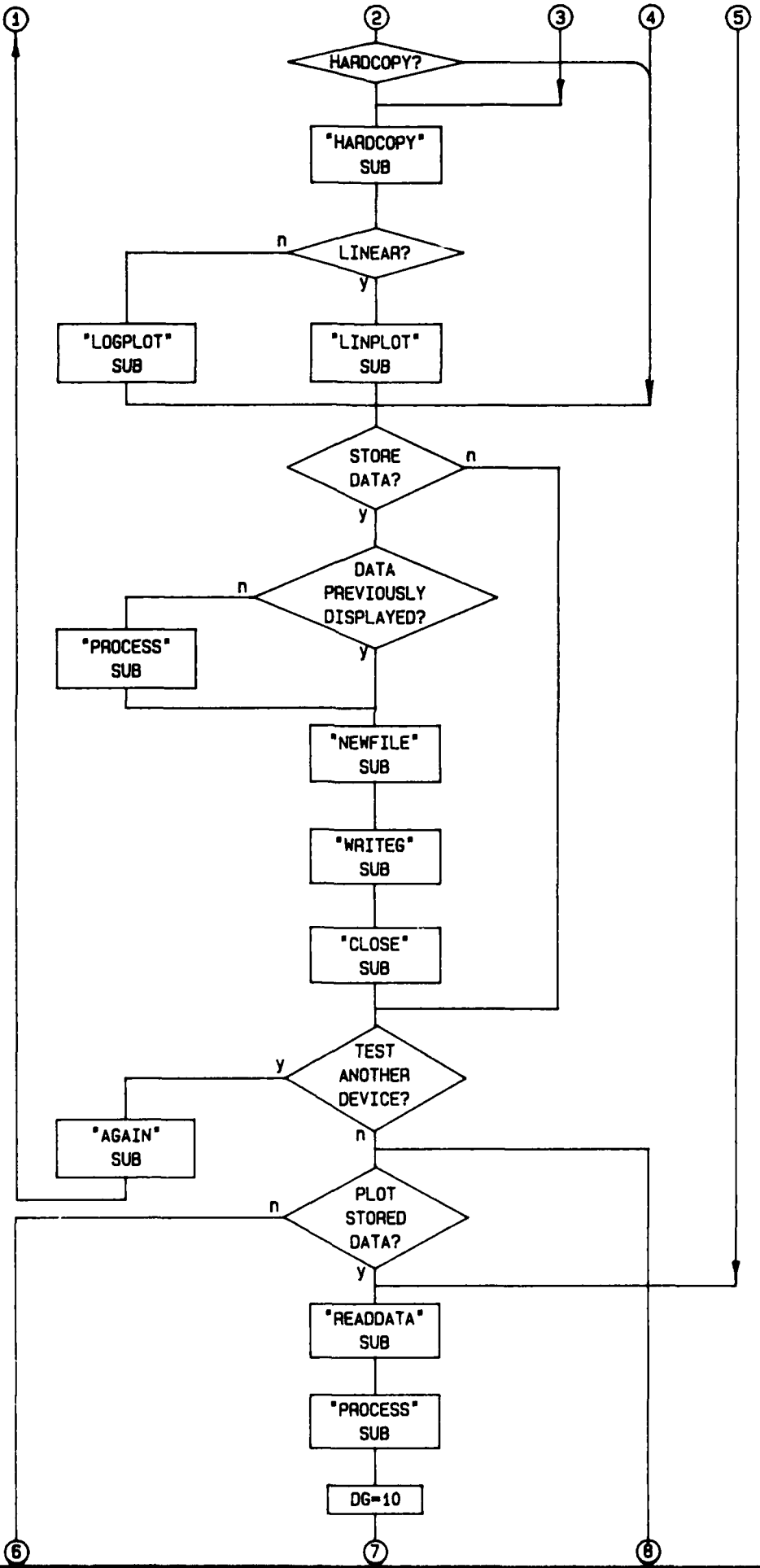
REFERENCES

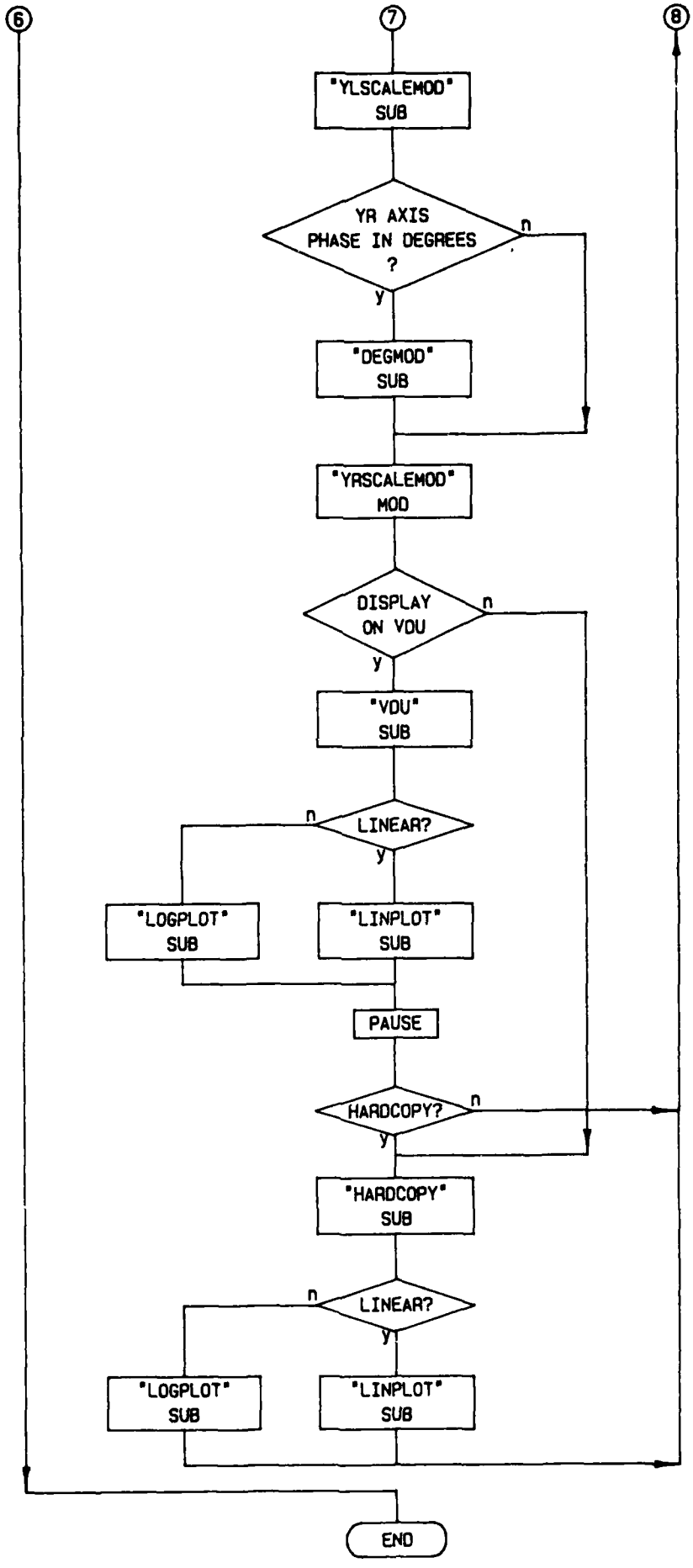
1. Hewlett Packard. HP-86/87 Operating and Programming Manual.
   Hewlett Packard Ltd. USA. 1982

2. Hewlett Packard. Operation and Service Manual, Model 4192A LF impedance analyzer.
   Yokagawa-Hewlett Packard Ltd. Tokyo. 1982

APPENDIX 1-Software flowchart and listing




1
2
3
4
5
HARDCOPY?
"HARDCOPY" SUB
n
LINEAR?
y
"LOGPLOT" SUB
"LINPLOT" SUB
STORE DATA?
n
y
DATA PREVIOUSLY DISPLAYED?
n
y
"PROCESS" SUB
"NEWFILE" SUB
"WRITEG" SUB
"CLOSE" SUB
TEST ANOTHER DEVICE?
y
n
"AGAIN" SUB
PLOT STORED DATA?
n
y
"READDATA" SUB
"PROCESS" SUB
DG=10
6
7
8


6
7
8
"YLSCALEMOD" SUB
YR AXIS PHASE IN DEGREES ?
n
y
"DEGMOD" SUB
"YRSCALEMOD" MOD
DISPLAY ON VDU
n
y
"VDU" SUB
n
LINEAR?
y
"LOGPLOT" SUB
"LINPLOT" SUB
PAUSE
HARDCOPY?
n
y
"HARDCOPY" SUB
n
LINEAR?
y
"LOGPLOT" SUB
"LINPLOT" SUB
END

```
10 REM          ******************** IMPSTORE ***********************************
20 PAGESIZE 16
30 PRINTER IS 300
40 CLEAR
50 DIM A$(151)[50]
60 DIM B$[50]
70 DIM AA(151),BB(151),FR(151)
80 OPTION BASE 0
90 DISP "            *** IMPEDANCE MEASURE STORE AND PLOT PROGRAM ***"
100 DISP "     Do you wish to measure (M) or display stored data?  (D)"
110 INPUT MD$
120 IF MD$#"M" AND MD$#"D" THEN BEEP @ GOTO 100
130 IF MD$="M" THEN GOSUB MEASURE  ELSE PLO$="Y" @ GOTO 720
140 REM    ****** MEASURE sets up parameters to be measured and measures ******
150 DISP @ DISP @ DISP "     Do you wish to display plot?    (Y/N)"
160 INPUT REP1$
170 IF REP1$#"Y" AND REP1$#"N" THEN BEEP @ GOTO 150
180 IF REP1$="Y" THEN GOSUB PROCESS  ELSE GOTO 500
190 REM             ****** PROCESS converts raw analyser data to numbers ******
200 DG=10
210 REM                    ****** Sets right hand Y axis to ten divisions ******
220 GOSUB YLSCALEMOD  !                      ****** LEFT  AXIS SCALE MOD  ******
230 REM              ****** YLSCALEMOD modifies left hand Y scale range ******
240 IF LAB2$="PHASE DEG" THEN GOSUB DEGMOD  !   *** RIGHT AXIS 10 TO 6 DIVS ***
250 REM ** DEGMOD is 6 divisions option for Y scale if it is phase in degrees *
260 GOSUB YRSCALEMOD  !                       ****** RIGHT AXIS SCALE MOD ******
270 REM             ****** YRSCALEMOD modifies right hand Y scale range ******
280 DISP "   Do you wish to display on VDU (V) or get a hard copy (H)? (V/H)"
290 INPUT REP5$
300 IF REP5$#"V" AND REP5$#"H" THEN BEEP @ GOTO 280
310 IF REP5$="H" THEN 440
320 GOSUB VDU
330 REM        ****** VDU sets up graphics limits for display on screen  ******
340 IF FL$="LIN" THEN GOSUB LINPLOT
350 REM         ****** LINPLOT plots data when frequency scale is linear ******
360 IF FL$="LOG" THEN GOSUB LOGPLOT
370 REM   ****** LOGPLOT plots data when frequency scale is logarithmic *******
380 PAUSE
390 ALPHA
400 DISP "     Do you want a hardcopy ?       (Y/N)"
410 INPUT RES$
420 IF RES$#"Y" AND RES$#"N" THEN BEEP @ GOTO 400
430 IF RES$="N" THEN 500
440 GOSUB HARDCOPY
450 REM        ****** HARDCOPY sets up graphics limits for plotting data ******
460 IF FL$="LIN" THEN GOSUB LINPLOT
470 REM         ****** LINPLOT plots data when frequency scale is linear ******
480 IF FL$="LOG" THEN GOSUB LOGPLOT
490 REM    ****** LOGPLOT plots data when frequency scale is logarithmic ******
500 DISP "     Do you wish to store data?    (Y/N)"
510 INPUT REP2$
520 IF REP2$#"Y" AND REP2$#"N" THEN BEEP @ GOTO 500
530 IF REP2$="Y" THEN 540 ELSE GOTO 630
540 IF REP1$="Y" THEN 570
550 GOSUB PROCESS
560 REM             ****** PROCESS converts raw analyser data to numbers ******
570 GOSUB NEWFILE
580 REM                          ****** NEWFILE creates datafile on disc ******
590 GOSUB WRITEG
600 REM             ****** WRITEG writes data to file created by NEWFILE ******
610 GOSUB CLOSE
620 REM              ****** CLOSE closes the data file written by WRITEG ******
630 DISP "     Do you wish to test another device?    (Y/N)"
640 INPUT REP4$
650 IF REP4$#"Y" AND REP4$#"N" THEN BEEP @ GOTO 630
660 IF REP4$="Y" THEN GOSUB AGAIN  ELSE 690
670 REM                                  ****** AGAIN is a dummy routine ******
680 GOTO 90
690 DISP "     Do you wish to plot any of the stored data?      (Y/N)"
```

```
700 INPUT PLO$
710 IF PLO$#"Y" AND PLO$#"N" THEN BEEP @ GOTO 690
720 IF PLO$="Y" THEN GOSUB READDATA  ELSE 1080
730 REM              ****** READDATA reads data previously on disc stored ******
740 GOSUB PROCESS
750 REM ************ PROCESS converts raw analyser data to numbers ************
760 DG=10
770 REM              ****** DG=10 sets right hand Y axis to ten divisions ******
780 GOSUB YLSCALEMOD  !                        ****** LEFT  AXIS SCALE MOD ******
790 REM  ************** YLSCALEMOD modifies left hand Y scale range ************
800 IF LAB2$="PHASE DEG" THEN GOSUB DEGMOD  !   *** RIGHT AXIS 10 TO 6 DIVS ***
810 REM ** DEGMOD is 6 divisions option for Y scale if it is phase in degrees *
820 GOSUB YRSCALEMOD  !                        ****** RIGHT AXIS SCALE MOD ******
830 REM              ****** YRSCALEMOD modifies right hand Y scale range ******
840 DISP "   Do you wish to display on VDU (V) or get a hard copy (H)? (V/H)"
850 INPUT REP6$
860 IF REP6$#"V" AND REP6$#"H" THEN BEEP @ GOTO 840
870 IF REP6$="H" THEN 1010
880 GOSUB VDU
890 REM         ****** VDU sets up graphics limits for display on screen  ******
900 IF FL$="LIN" THEN GOSUB LINPLOT
910 REM         ****** LINPLOT plots data when frequency scale is linear *******
920 IF FL$="LOG" THEN GOSUB LOGPLOT
930 REM    ****** LOGPLOT plots data when frequency scale is logarithmic ******
940 PAUSE
950 REM "      ****** Pause to enable operator to view the plot on screen ******
960 ALPHA
970 DISP "     Do you want a hardcopy ?       (Y/N)"
980 INPUT RES1$
990 IF RES1$#"Y" AND RES1$#"N" THEN BEEP @ GOTO 970
1000 IF RES1$="N" THEN 690
1010 GOSUB HARDCOPY
1020 REM        ****** HARDCOPY sets up graphics limits for plotting data ******
1030 IF FL$="LIN" THEN GOSUB LINPLOT
1040 REM         ****** LINPLOT plots data when frequency scale is linear ******
1050 IF FL$="LOG" THEN GOSUB LOGPLOT
1060 REM ****** LOGPLOT plots data when frequency scale is logarithmic ********
1070 GOTO 690
1080 DISP "   END OF PROGRAM to measure or plot press RUN key"
1090 END
1100 !
1110 !
1120 MEASURE: !  ******************MEASURE SUBROUTINE*************************
1130 REM DISP"analyzer addr=317 , plotter addr=305.  What do you wish to plot ?"
1140 I=317
1150 CLEAR I
1160 REMOTE I
1170 REM OUTPUT I ;"S1"              ******  Remove for analyser self test ******
1180 REM                             ****** Choose parameter to be measured *****
1190 DISP "To measure         Type"
1200 DISP "IMPEDANCE           Z"
1210 DISP "ADMITTANCE          Y"
1220 DISP "RESISTANCE          R"
1230 DISP "CONDUCTANCE         G"
1240 DISP "INDUCTANCE          L"
1250 DISP "CAPACITANCE         C"
1260 DISP "GAIN               B-A"
1270 DISP "REF   AMP           A"
1280 DISP "INPUT AMP           B"
1290  INPUT ANS1$
1300 Z: IF ANS1$="Z" THEN OUTPUT I ;"A1C2" @ LAB1$="IMPEDANCE Z" @ GOTO DEG1
1310 REM      ***** Sets analyser to measure Z/Y series equivalent circuit *****
1320 Y: IF ANS1$="Y" THEN OUTPUT I ;"A1C3" @ LAB1$="ADMITTANCE Y" @ GOTO DEG1
1330 REM **** Sets the analyser to measure Z/Y parallel equivalent circuit ****
1340 GOTO R
1350 DEG1:  DISP "For angles in     Type"
1360 REM                             ***** Sets phase in degrees or radians *****
1370 DISP "   DEGREES           D"
1380 DISP "   RADIANS           R"
```

```
1390 INPUT ANS$
1400 ON ERROR GOTO DEG1
1410 REM                    ******* Trap errors so program does not abort ******
1420 IF ANS$[1,1]="D" THEN OUTPUT I ;"B1" @ LAB2$="PHASE DEG" @ GOTO RES0
1430 REM                  **** Sets the analyser to measure phase in DEGREES ****
1440 IF ANS$[1,1]="R" THEN OUTPUT I ;"B2" @ LAB2$="PHASE RAD" @ GOTO RES0
1450 REM                  **** Sets the analyser to measure phase in RADIANS ****
1460 GOTO DEG1
1470 R: IF ANS1$="R" THEN DISP "(PLUS REACTANCE    X)" @ OUTPUT I ;"A2B1C2" @ LA
B1$="RESISTANCE R" @ LAB2$="REACTANCE X" @ GOTO RES0
1480 REM                  ****** Sets the analyser to measure R/G , phase
in DEGREES  , series equivalent circuit ******
1490 G: IF ANS1$="G" THEN DISP "( + SUSCEPTANCE B)" @ OUTPUT I ;"A2B3C3" @ LAB1$
="CONDUCTANCE G" @ LAB2$="SUSCEPTANCE B" @ GOTO RES0
1500 REM              **** Sets the analyser to measure R/G ,
R/G , parallel equivalent circuit ******
1510 L: IF ANS1$="L" THEN OUTPUT I ;"A3" @ LAB1$="INDUCTANCE L" @ GOTO DEG2
1520 REM                              **** Sets the analyser to measure L ******
1530 C: IF ANS1$="C" THEN OUTPUT I ;"A4" @ LAB1$="CAPACITANCE C" @ GOTO DEG2
1540 REM                              **** Sets the analyser to measure C ******
1550 GOTO BA
1560 DEG2:  DISP "   For            Type"
1570 REM                       ****** Select right hand Y axis parameter ******
1580 DISP "QUALITY            Q"
1590 DISP "DISSIPATION        D"
1600 DISP "RESISTANCE         R"
1610 DISP "CONDUCTANCE        G"
1620 DISP @ INPUT ANS$
1630 ON ERROR GOTO DEG2
1640 REM                    ******* Trap errors so program does not abort ******
1650 IF ANS$="Q" THEN OUTPUT I ;"B1C2" @ LAB2$="QUALITY Q" @ GOTO RES0
1660 REM     ***** Sets analyser to measure Q , series equivalent circuit *****
1670 IF ANS$="D" THEN OUTPUT I ;"B2C2" @ LAB2$="DISSIPATION D" @ GOTO RES0
1680 REM     ***** Sets analyser to measure D , series equivalent circuit *****
1690 IF ANS$="R" THEN OUTPUT I ;"B3C2" @ LAB2$="RESISTANCE R" @ GOTO RES0
1700 REM     ***** Sets analyser to measure R/G ,series equivalent circuit ****
1710 IF ANS$="G" THEN OUTPUT I ;"B3C3" @ LAB2$="CONDUCTANCE G" @ GOTO RES0
1720 REM   ***** Sets analyser to measure R/G ,parallel equivalent circuit ****
1730 BEEP 100,100 @ GOTO DEG2
1740 BA: IF ANS1$="B-A" THEN OUTPUT I ;"A5" @ LAB1$="GAIN dB" ELSE A
1750 REM                        ****** Sets analyser to measure B-A (dB) ******
1760 REM                       ****** Select right hand Y axis parameter ******
1770 DEG3:  DISP "   For            Type"
1780 DISP "GROUP DELAY         G"
1790B DISP "DEGREES             D"
1800 DISP "RADIANS             R"
1810 DISP @ INPUT ANS$
1820 ON ERROR GOTO BA
1830 REM                    ******* Trap errors so program does not abort ******
1840 IF ANS$[1,1]="G" THEN OUTPUT I ;"B1" @ LAB2$="GROUP DELAY S" @ GOTO RES0
1850 REM                       ****** Sets analyser to measure GROUP DELAY******
1860 IF ANS$[1,1]="D" THEN OUTPUT I ;"B2" @ LAB2$="PHASE DEG" @ GOTO RES0
1870 REM                    ****** Sets analyser to measure phase DEGREES ******
1880 IF ANS$[1,1]="R" THEN OUTPUT I ;"B3" @ LAB2$="PHASE RAD" @ GOTO RES0
1890 REM                    ****** Sets analyser to measure phase RADIANS ******
1900 GOTO DEG3
1910 A: IF ANS1$="A" THEN OUTPUT I ;"A6" @ LAB1$="REF I/P" @ GOTO DEG4
1920 REM                  ****** Sets analyser to measure INPUT A dBm/dBV ******
1930 B: IF ANS1$="B" THEN OUTPUT I ;"A7" @ LAB1$="TEST I/P" @ GOTO DEG4
1940 REM                  ****** Sets analyser to measure INPUT B dBm/dBV ******
1950 BEEP 100,100 @ GOTO 1190
1960 DEG4:  DISP "   For            Type" !      ***** Gain in dBv or dBm *****
1970 DISP "dBv                V"
1980 DISP "dBm                M"
1990 DISP @ INPUT ANS$
2000 ON ERROR GOTO DEG4
2010 REM                    ******* Trap errors so program does not abort ******
2020 IF ANS$[1,1]="M" THEN OUTPUT I ;"N1" @ LAB1$=LAB1$&" dBm" @ LAB2$="" @ GOTO
RES0
```

```
2030 REM                        ****** Sets analyser to measure GAIN in dBm ******
2040 IF ANS$[1,1]="V" THEN OUTPUT I ;"M2" @ LAB1$=LAB1$&" dBv" @ LAB2$="" @ GOTO
RESO
2050 REM                        ****** Sets analyser to measure GAIN in dBV ******
2060 GOTO DEG4
2070 RESO: DISP "For resolution              Type"
2080 REM                                        ***** Sets up resolution *****
2090 DISP "HIGH SPEED                    S"
2100 DISP "ACCURACY                      A"
2110 DISP "NORMAL                        N"
2120 INPUT ANS$
2130 ON ERROR GOTO RESO
2140 REM                       ******* Trap errors so program does not abort ******
2150 IF ANS$[1,1]="S" THEN 2190
2160 IF ANS$[1,1]="A" THEN 2210
2170 IF ANS$[1,1]="N" THEN 2230
2180 IF ANS$[1,1]="" THEN 2230
2190 OUTPUT I ;"H1" @ GOTO HORI
2200 REM                                ****** Sets analyser to HIGH SPEED ON ******
2210 OUTPUT I ;"V1" @ GOTO HORI
2220 REM                                  ****** Sets analyser to AVERAGE ON ******
2230 HORI: DISP "For freq scale            type"
2240 REM                                 ***** Specifies log or lin freq scale *****
2250 DISP "   LINEAR                    LIN"
2260 DISP "     LOG                     LOG"
2270 INPUT ANS$
2280 ON ERROR GOTO HORI
2290 REM                       ******* Trap errors so program does not abort ******
2300 IF ANS$[3,3]="N" THEN OUTPUT I ;"GOEN" @ FL$="LIN" @ GOTO LINFREQ
2310 REM                                  ****** Sets analyser to LOG SWEEP OFF *****
2320 IF ANS$[3,3]="G" THEN FL$="LOG" @ GOTO LOGFREQ
2330 GOTO HORI
2340 LINFREQ: DISP @ DISP "What is the lower frequency in KHz";
2350 REM                                    *****Sets up upper and lower freq *****
2360 INPUT TF
2370 IF TF<.005 THEN DISP "Not less than .005" @ BEEP 100,100 @ GOTO LINFREQ
2380 OUTPUT I ;"TF";TF;"EN"
2390 REM                                  ****** Sets analyser START FREQUENCY ******
2400 OUTPUT I ;"FR";TF;"EN"
2410 REM                                  ****** Sets analyser SPOT FREQUENCY ******
2420 DISP "What is the higher frequency in kHz";
2430 INPUT PF
2440 IF PF>13000 THEN DISP "Not more than 13000" @ BEEP 100,100 @ GOTO LINFREQ
2450 IF PF<TF THEN DISP "That's NOT higher !!!" @ BEEP 100,100 @ GOTO LINFREQ
2460 IF PF=TF THEN DISP "SAME frequency !!!" @ BEEP 100,100 @ GOTO LINFREQ
2470 OUTPUT I ;"PF";PF;"EN"
2480 REM                                  ****** Sets analyser STOP FREQUENCY ******
2490 POINTS: DISP "How many steps";
2500 INPUT ST
2510 IF ST>150 THEN DISP "Too many" @ BEEP 100,100 @ GOTO POINTS
2520 SF=ABS (PF-TF)/ST
2530  OUTPUT I USING 2550 ; SF
2540 REM                                  ****** Sets analyser STEP FREQUENCY ******
2550  IMAGE "SF",ZZZZ.DDDD,"EN",K
2560  OUTPUT I ;"T3F1W1W2" @ GOTO SWEEP
2570 REM          ****** Sets analyser TRIGGER HOLD/MANUAL ,DISPLAY DATA
A/B/C , AUTO SWEEP , STEP FREQUENCY UP ******
2580 LOGFREQ: DISP "What is the lower frequency in KHz"
2590 INPUT START
2600 IF START<.01 THEN START=.01 @ DISP "Lowest frequency is .01 KHz"
2610 DISP "What is the higher frequency in KHz"
2620 INPUT FINISH
2630 IF FINISH>13000 THEN FINISH=13000 @ DISP "Highest frequency is 13000"
2640 IF START=FINISH THEN BEEP 100,100 @ DISP "SAME frequency" @ GOTO LOGFREQ
2650 IF START>FINISH THEN BEEP 100,100 @ DISP "Higher frequency was lower than l
ow" @ GOTO LOGFREQ
2660 STAR=INT (LGT (START)) !   *** Rounds to largest decade <or=lower freq ***
2670 FINI=CEIL (LGT (FINISH)) ! *** Rounds to smallest decade >or= upper freq *
2680 DECS=FINI-STAR !    *** Calculates the number of decades in freq range ***
```

```
2690 TF=10↑STAR !                          *** Calculates the rounded lower freq ***
2700 PF=10↑FINI !                          *** Calculates the rounded upper freq ***
2710 OUTPUT I ;"TF";TF;"EN"
2720 REM                                 ****** Sets analyser START FREQUENCY ******
2730 OUTPUT I ;"FR";TF;"EN"
2740 REM                                  ****** Sets analyser SPOT FREQUENCY ******
2750 OUTPUT I ;"PF";PF;"EN"
2760 REM                                  ****** Sets analyser STOP FREQUENCY ******
2770 OUTPUT I ;"G1EN"
2780 REM                                    ****** Sets analyser LOG SWEEP ON ******
2790 OUTPUT I ;"T3F1W1W2"
2800 REM          ****** Sets analyser TRIGGER HOLD/MANUAL ,DISPLAY DATA
A/B/C , AUTO SWEEP , STEP FREQUENCY UP ******
2810 SWEEP: DISP "SWEEPING ........"
2820 REM                  ****** Sweep , trigger analyser , measure data  ******
2830  FOR N=0 TO 150
2840 OUTPUT I ;"EX"
2850 REM                                          ****** Sets analyser EXECUTE ******
2860 A=SPOLL (I)
2870 REM   ****** Conducts a serial poll of the analyser for handshaking ******
2880 IF BIT (A,4)#1 THEN 2920
2890 ENTER I ; B$
2900 A$(N)=B$
2910 NEXT N
2920 ARM=N-1
2930 OFF ERROR
2940 REM                                                ****** Error trap off *******
2950 DISP "SWEEPING COMPLETED     TAKEN";N;"READINGS"
2960 RETURN
2970 PROCESS: !  ****************PROCESS SUBROUTINE****************************
2980 REM            ****** PROCESS converts raw analyser data to numbers ******
2990 PRINTER IS 300
3000 FOR M=0 TO ARM
3010 REM DISP A$(M) ! REMOVE REM TO DISPLAY OUTPUT OF ANALYZER
3020 REM PRINT A$(M) ! REMOVE REM TO PRINT OUTPUT OF ANALYZER
3030 NEXT M
3040 DISP "CONVERTING DATA TO NUMBERS ........"
3050 REM                           ****** Extract data from analyser output ******
3060 FOR M=0 TO ARM
3070 AA(M)=VAL (A$(M)[5,15]) @ BB(M)=VAL (A$(M)[21,31]) @ FR(M)=VAL (A$(M)[34,43
])
3080 REM DISP AA(M),BB(M),FR(M) ! REMOVE REM TO DISPLAY VALUES
3090 NEXT M
3100 DISP "FINDING MAX/MINS ........"
3110 MAXAA=AA(0) @ MAXBB=BB(0) @ MAXFR=PF @ MINAA=AA(0) @ MINBB=BB(0) @ MINFR=TF
3120 FOR M=0 TO ARM
3130 MAXAA=MAX (MAXAA,AA(M)) @ MINAA=MIN (MINAA,AA(M))
3140 MAXBB=MAX (MAXBB,BB(M)) @ MINBB=MIN (MINBB,BB(M))
3150 NEXT M
3160 MINBBB=MINBB @ MAXBBB=MAXBB
3170 DISP
3180 REM ** Display max/min measured values which become plot default values **
3190 DISP "MAX    ";LAB1$;"=";MAXAA;"    ";LAB2$;"=";MAXBB,"    ";"FREQ=";MAXFR
3200 DISP "MIN    ";LAB1$;"=";MINAA;"    ";LAB2$;"=";MINBB,"    ";"FREQ=";MINFR
3210 RETURN
3220 LINPLOT: !  ****************LINPLOT SUBROUTINE*************************
3230 REM ********** LINPLOT plots data when frequency scale is linear *********
3240 LOCATE PXMIN,PXMAX,PYMIN,PYMAX
3250 REM                                        ****** Sets up plot limits ******
3260 SCALE MINFR,MAXFR,MINAA,MAXAA
3270 REM                                          ****** Sets up plot axes ******
3280 FXD 1,1
3290 LAXES -((MAXFR-MINFR)/10),(MAXAA-MINAA)/10,MINFR,MINAA
3300 REM                                            ****** Label plot axes ******
3310 MOVE MINFR,MAXAA+(MAXAA-MINAA)/20
3320 LORG 5
3330 LABEL LAB1$
3340 MOVE (MAXFR+MINFR)/2,MINAA-(MAXAA-MINAA)/10
3350 LORG 5
```

```
3360 LABEL "FREQUENCY KHz"
3370 REM                                                ****** Plot data ******
3380 FOR M=0 TO ARM
3390 PLOT FR(M),AA(M)
3400 NEXT M
3410 IF ANS1$="A" THEN GOTO FINISH
3420 IF ANS1$="B" THEN GOTO FINISH
3430 SCALE MINFR,MAXFR,MINBB,MAXBB
3440 REM                                          ****** Sets up plot axes ******
3450 PEN 2
3460 YAXIS MAXFR,(MAXBB-MINBB)/DG,MINBB,MAXBB
3470 LORG 2
3480 FOR Y=MINBB TO MAXBB STEP (MAXBB-MINBB)/DG
3490 MOVE MAXFR+(MAXFR-MINFR)/100,Y
3500 REM                                           ****** Label plot axes ******
3510 LABEL Y
3520 NEXT Y
3530 MOVE MAXFR,MAXBB+(MAXBB-MINBB)/20
3540 LORG 5
3550 PEN 2
3560 LABEL LAB2$
3570 SETUU
3580 REM                                                ****** Plot data ******
3590 FOR M=0 TO ARM
3600 PLOT FR(M),BB(M)
3610 NEXT M
3620 IF DG=6 THEN 3650
3630 GOTO 3680
3640 REM                                        ****** Draw zero phase line ******
3650 MOVE MINFR,(MAXBB+MINBB)/2
3660 LINE TYPE 4
3670 DRAW MAXFR,(MAXBB+MINBB)/2
3680 GOTO FINISH
3690 FINISH:
3700 RETURN
3710 LOGPLOT: !  ****************LOGPLOT SUBROUTINE**************************
3720 REM   ****** LOGPLOT plots data when frequency scale is logarithmic ******
3730 LOCATE PXMIN,PXMAX,PYMIN,PYMAX
3740 REM                                          ****** Sets up plot limits ******
3750 SCALE LGT (MINFR),LGT (MAXFR),MINAA,MAXAA
3760 REM                                           ****** Sets up plot axes ******
3770 FXD 1,1
3780 XAXIS MINAA,(LGT (MAXFR)-LGT (MINFR))/DECS,LGT (MINFR),LGT (MAXFR)
3790 L=MINFR
3800 FOR X=LGT (MINFR) TO LGT (MAXFR) STEP (LGT (MAXFR)-LGT (MINFR))/DECS
3810 MOVE X,MINAA-(MAXAA-MINAA)/35
3820 LORG 6
3830 LABEL L
3840 FOR I=2 TO 9
3850 IF X>= LGT (MAXFR) THEN 3920
3860 MOVE X+(LGT (MAXFR)-LGT (MINFR))/DECS*LGT (I),MINAA
3870 SETGU
3880 IPLOT 0,1,-1
3890 IMOVE 0,-1
3900 SETUU
3910 NEXT I
3920 L=L*10
3930 NEXT X
3940 MOVE (LGT (MAXFR)+LGT (MINFR))/2,MINAA-(MAXAA-MINAA)/10
3950 LORG 6
3960 REM                                           ****** Label plot axes ******
3970 LABEL "FREQUENCY KHz"
3980 YAXIS LGT (MINFR),(MAXAA-MINAA)/10,MINAA,MAXAA
3990 LORG 8
4000 FOR Y=MINAA TO MAXAA STEP (MAXAA-MINAA)/10
4010 MOVE LGT (MINFR),Y
4020 LABEL Y
4030 NEXT Y
4040 MOVE LGT (MINFR),MAXAA+(MAXAA-MINAA)/20
```

```
4050 LORG 4
4060 LABEL LAB1$
4070 PEN 1
4080 REM                                                ****** Plot data ******
4090 FOR M=0 TO ARM
4100 PLOT LGT (FR(M)),AA(M)
4110 NEXT M
4120 IF ANS1$="A" THEN GOTO FINISH
4130 IF ANS1$="B" THEN GOTO FINISH
4140 PEN 2
4150 SCALE LGT (MINFR),LGT (MAXFR),MINBB,MAXBB
4160 REM                                          ****** Sets up plot scale ******
4170 YAXIS LGT (MAXFR),(MAXBB-MINBB)/DG,MINBB,MAXBB
4180 REM                                           ****** Sets up plot axes ******
4190 LORG 2
4200 FOR Y=MINBB TO MAXBB STEP (MAXBB-MINBB)/DG
4210 MOVE LGT (MAXFR)+(LGT (MAXFR)-LGT (MINFR))/100,Y
4220 REM                                             ****** Label plot axes ******
4230 LABEL Y
4240 NEXT Y
4250 MOVE LGT (MAXFR),MAXBB+(MAXBB-MINBB)/20
4260 LORG 4
4270 LABEL LAB2$
4280 REM                                                ****** Plot data ******
4290 FOR M=0 TO ARM
4300 PLOT LGT (FR(M)),BB(M)
4310 NEXT M
4320 IF DG=6 THEN 4350
4330 GOTO 4380
4340 REM                                        ****** Draw zero phase line ******
4350 MOVE LGT (MINFR),(MAXBB+MINBB)/2
4360 LINE TYPE 4
4370 DRAW LGT (MAXFR),(MAXBB+MINBB)/2
4380 RETURN
4390 YLSCALEMOD: !  ********** YL AXIS SCALE MODIFICATION SUBROUTINE **********
4400 REM  ****** YLSCALEMOD enables the left hand Y axis scale to be
modified from the default values ( measured min and max ) ******
4410 DISP @ DISP "Do you wish to modify the Y axis (";LAB1$;")scale ?    (Y/N)"
4420 INPUT ALT1$
4430 IF ALT1$="Y" THEN 4470
4440 IF ALT1$="N" THEN RETURN
4450 GOTO 4410
4460 REM  **** Display the default min/max values of Y (measured max/min) *****
4470 DISP "THE CURRENT Y SCALE VALUES OF ";LAB1$;" ARE  ";MINAA;"    ";MAXAA
4480 REM                      ****** Modification of MIN value of Y scale ******
4490 DISP "What minimum Y scale value do you want ?"
4500 INPUT YMIN
4510 IF YMIN<= MINAA THEN 4560
4520 DISP "THIS IS GREATER THAN THE MEASURED MIN VALUE ARE YOU SURE ? (Y/N)"
4530 INPUT ALT2$
4540 IF ALT2$="Y" THEN 4560
4550 GOTO 4470
4560 MINAA=YMIN
4570 DISP "THE CURRENT Y SCALE VALUES OF ";LAB1$;" ARE  ";MINAA;"    ";MAXAA
4580 REM                      ****** Modification of MAX value of Y scale ******
4590 DISP "What maximum Y scale value do you want ?"
4600 INPUT YMAX
4610 IF YMAX>= MAXAA THEN 4660
4620 DISP "THIS IS LESS THAN THE MEASURED MAX VALUE ARE YOU SURE?  (Y/N)"
4630 INPUT ALT3$
4640 IF ALT3$="Y" THEN 4660
4650 GOTO 4570
4660 MAXAA=YMAX
4670 RETURN
4680 YRSCALEMOD: !  ********** YR AXIS SCALE MODIFICATION SUBROUTINE **********
4690 REM ****** YRSCALEMOD enables the right hand Y axis scale to be
modified from the default values ( measured min and max ) ******
4700 DISP
4710 DISP
```

```
4720 DISP "Do you wish to modify the Y axis (";LAB2$;")scale ?      (Y/N)"
4730 INPUT ALT4$
4740 IF ALT4$="Y" THEN 4780
4750 IF ALT4$="N" THEN RETURN
4760 GOTO 4720
4770 REM  **** Display the default min/max values of Y (measured max/min) *****
4780 DISP "THE CURRENT Y SCALE VALUES OF ";LAB2$;" ARE  ";MINBB;"    ";MAXBB
4790 REM                    ****** Modification of MIN value of Y scale ******
4800 DISP "What minimum Y scale value do you want ?"
4810 INPUT YRMIN
4820 IF YRMIN<= MINBBB THEN 4870
4830 DISP "THIS IS GREATER THAN THE MEASURED MIN VALUE ARE YOU SURE?   (Y/N)"
4840 INPUT ALT5$
4850 IF ALT5$="Y" THEN 4870
4860 GOTO 4780
4870 MINBB=YRMIN
4880 DISP "THE CURRENT Y SCALE VALUES OF ";LAB2$;" ARE  ";MINBB;"    ";MAXBB
4890 REM                    ****** Modification of MAX value of Y scale ******
4900 DISP "What maximum Y scale value do you want ?"
4910 INPUT YRMAX
4920 IF YRMAX>= MAXBBB THEN 4970
4930 DISP "THIS IS LESS THAN THE MEASURED MAX VALUE ARE YOU SURE?   (Y/N)"
4940 INPUT ALT6$
4950 IF ALT6$="Y" THEN 4970
4960 GOTO 4880
4970 MAXBB=YRMAX
4980 RETURN
4990 DEGMOD: !  *************** YR AXIS MOD FROM 10 TO 6 DIVISIONS ************
5000 REM   ****** DEGMOD enables the right hand axis to be modified from
10 to 6 divisions when the axis is phase angle in degrees ******
5010 DISP
5020 DISP
5030 DISP "Do you wish to modify the Y axis (";LAB2$;")scale to six divisions"
5040 DISP "This enables phase to be displayed from -90 to +90 Degrees"
5050 DISP "in 30 Degree steps   (Y/N)"
5060 INPUT ALTD$
5070 IF ALTD$="Y" THEN 5100
5080 IF ALTD$="N" THEN DG=10 @ RETURN
5090 GOTO 5030
5100 DG=6
5110 REM           ****** DG=6 sets the right hand axis to six divisions ******
5120 REM   ****** Set default values of right hand axis to =/-90 degrees ******
5130 MINBBB=MINBB @ MINBB=-90
5140 MAXBBB=MAXBB @ MAXBB=90
5150 REM      ****** Display the measured min/max values (MINBBB/MAXBBB) ******
5160 DISP "THE MIN VALUE OF ";LAB2$;" IS ";MINBBB;"  THE MAX VALUE OF ";LAB2$;"
IS ";MAXBBB
5170 REM ***** Display the plot default min/max values (-90/+90 degrees) ******
5180 DISP "THE ";LAB2$;" SCALE RANGE IS ";MINBB;"TO";MAXBB;"IN 30 DEGREE STEPS"
5190 RETURN
5200 HARDCOPY: PLOTTER IS 305 !  *********** HARDCOPY ************************
5210 REM            ****** HARDCOPY sets plotter parameters to plot data ******
5220 LIMIT 0,270,5,185
5230 REM        ****** Set plot limits , change for different sized plot ******
5240 PEN 1
5250 REM FRAME
5260 REM   ****** Set location of axes , change for different sized plot ******
5270 PXMIN=15
5280 PXMAX=135
5290 PYMIN=10
5300 PYMAX=90
5310 CSIZE 3
5320 RETURN
5330 VDU: PLOTTER IS 1 !  ******************** VDU ****************************
5340 REM             ****** VDU sets graphics parameters to display data ******
5350 CLEAR
5360 DISP @ DISP @ DISP @ DISP @ DISP @ DISP @ DISP
5370 DISP "             After viewing plot press CONT to continue"
5380 REM *** 3.5 Sec pause to enable operator to read message on screen *******
```

```
5390 WAIT 3500
5400 GCLEAR
5410 GRAPHALL
5420 LIMIT 0,171,0,75
5430 REM        ****** Set plot limits , change for different sized plot ******
5440 PEN 1
5450 REM FRAME
5460 REM   ****** Set location of axes , change for different sized plot ******
5470 PXMIN=22
5480 PXMAX=205
5490 PYMIN=12
5500 PYMAX=92
5510 CSIZE 5
5520 RETURN
5530 NEWFILE: !  ***************** NEWFILE SUBROUTINE ***************************
5540 REM ****************** NEWFILE creates datafile on disc ******************
5550 DISP "     Enter datafile title"
5560 INPUT NAME$
5570 REM                    ******* Trap errors so program does not abort ******
5580 ON ERROR GOTO 5650
5590 CREATE NAME$,20,256
5610 DISP "CREATING ";NAME$
5620 ASSIGN# 1 TO  NAME$
5630 OFF ERROR
5640 RETURN
5650 OFF ERROR
5660 REM                                ****** Display details of any errors ******
5670 IF ERRN =63 THEN DISP NAME$;" exists use a different name" ELSE DISP "ERROR
";ERRN ;"HAS OCCURED ON CREATING FILE at line";ERRL ;" in program"
5680 GOTO 5550
5690 WRITEG: !  ******************** WRITEG SUBROUTINE ***************************
5700 REM ************ WRITEG writes data to file created by NEWFILE *************
5710 DISP "     Enter datafile identification"
5720 INPUT IDENT$
5730 OFF ERROR
5740 REM                    ******* Trap errors so program does not abort ******
5750 ON ERROR GOTO 5870
5760 PRINT# 1 ; IDENT$
5770 PRINT# 1 ; LAB1$,LAB2$,MINFR,MAXFR,ARM,ANS1$,FL$,PF,TF
5780 IF FL$="LIN" THEN 5800
5790 PRINT# 1 ; DECS
5800 FOR N=0 TO ARM
5810 PRINT# 1 ; A$(N)
5820 NEXT N
5830 DISP "DATA STORED"
5840 OFF ERROR
5850 RETURN
5860 REM                                ****** Display details of any errors ******
5870 OFF ERROR @ PRINTER IS 1 @ PRINT "ERROR";ERRN ;"HAS OCCURED"
5880 IF ERRN =66 THEN DISP "FILE CLOSED,OPENING NEWFILE" @ GOSUB NEWFILE
5890 IF ERRN =71 THEN DISP "DATAFILE FULL, OPENING NEWFILE" @ GOSUB NEWFILE
5900 DISP "FILE HAS NOT BEEN WRITTEN"
5910 RETURN
5920 DISP "ERROR NUMBER ";ERRN ;" HAS OCCURED WHEN ENTERING IDENT TRY AGAIN"
5930 GOTO 5710
5940 CLOSE: !  ********************* CLOSE ROUTINE ****************************
5950 REM                    ******* Trap errors so program does not abort ******
5960 ON ERROR GOTO 6000
5970 ASSIGN# 1 TO  *
5980 DISP NAME$;" CLOSED"
5990 RETURN
6000 OFF ERROR
6010 REM                                ****** Display details of any errors ******
6020 IF ERRN =66 THEN DISP "FILE IS ALREADY CLOSED" @ RETURN
6030 DISP "     ";ERRN ;" Has occured at line";ERRL ;"file has NOT been closed"
6040 RETURN
6050 READDATA: !  ***************** READDATA SUBROUTINE ************************
6060 REM ************** READDATA reads data previously stored ******************
6070 DISP "     Which data file do you wish to access?"
```

```
6080 INPUT NAME$
6090 REM                    ******* Trap errors so program does not abort ******
6100 ON ERROR GOTO 6270
6110 ASSIGN# 1 TO  NAME$
6120 READ# 1 ; IDENT$
6130 READ# 1 ; LAB1$,LAB2$,MINFR,MAXFR,ARM,ANS1$,FL$,PF,TF
6140 IF FL$="LIN" THEN GOTO 6170
6150 READ# 1 ; DECS
6160 REM            ****** DECS is the number of decades for a log sweep ******
6170 FOR N=0 TO ARM
6180 READ# 1 ; A$(N)
6190 NEXT N
6200 PRINTER IS 1
6210 REM PRINT IDENT$
6220 REM PRINT LAB1$,LAB2$,MINFR,MAXFR,ARM,ANS1$,FL$,PF,TF,DECS
6230 REM FOR N=0 TO ARM @ PRINT A$(N) @ NEXT N
6240 PRINTER IS 301
6250 OFF ERROR
6260 RETURN
6270 OFF ERROR
6280 REM                              ****** Display details of any errors ******
6290 IF ERRN =71 THEN ARM=N-1 @ GOTO 6260
6300 IF ERRN =67 THEN DISP "    ";NAME$;" does not exist,try again" @ GOTO 6070
6310 DISP "   Error ";ERRN ;" Occured at line ";ERRL ;" Of program" @ GOTO 6070
6320 AGAIN: !  ********************* AGAIN SUBROUTINE *************************
6330 REM ********************** AGAIN is a dummy routine ***********************
6340 RETURN
```

APPENDIX II - Listing of program prompts and operator responses for a typical application

```
*** IMPEDANCE MEASURE STORE AND PLOT PROGRAM ***
Do you wish to measure (M) or display stored data?  (D)
?
M
To measure          Type
IMPEDANCE            Z
ADMITTANCE           Y
RESISTANCE           R
CONDUCTANCE          G
INDUCTANCE           L
CAPACITANCE          C
GAIN                B-A
REF   AMP            A
INPUT AMP            B
?
Z
For angles in       Type
DEGREES            D
RADIANS            R
?
D
For resolution                Type
HIGH SPEED                     S
ACCURACY                       A
NORMAL                         N
?
N
For freq scale          type
LINEAR                 LIN
LOG                    LOG
?
LOG
What is the lower frequency in KHz
?
1000
What is the higher frequency in KHz
?
13000
SWEEPING ........
SWEEPING COMPLETED      TAKEN 24 READINGS
Do you wish to display plot?     (Y/N)
?
Y
CONVERTING DATA TO NUMBERS ........
FINDING MAX/MINS ........
MAX     IMPEDANCE Z= 1211.2      PHASE DEG=85.78                    FREQ=100000
MIN     IMPEDANCE Z= 20.87      PHASE DEG=-86.93                    FREQ= 1000
Do you wish to modify the Y axis (IMPEDANCE Z)scale ?     (Y/N)
?
Y
THE CURRENT Y SCALE VALUES OF IMPEDANCE Z ARE   20.87      1211.2
What minimum Y scale value do you want ?
?
0
THE CURRENT Y SCALE VALUES OF IMPEDANCE Z ARE   0       1211.2
What maximum Y scale value do you want ?
?
1500
Do you wish to modify the Y axis (PHASE DEG)scale to six divisions
This enables phase to be displayed from -90 to +90 Degrees
in 30 Degree steps    (Y/N)
?
Y
THE MIN VALUE OF PHASE DEG IS -86.93   THE MAX VALUE OF PHASE DEG IS 85.78
THE PHASE DEG SCALE RANGE IS -90 TO 90 IN 30 DEGREE STEPS
```

```
Do you wish to modify the Y axis (PHASE DEG)scale ?      (Y/N)
?
N
Do you wish to display on VDU (V) or get a hard copy (H)? (V/H)
?
V
After viewing plot press CONT to continue
Do you want a hardcopy ?      (Y/N)
?
Y
Do you wish to store data?    (Y/N)
?
Y
Enter datafile title
?
EXAMPLE1
CREATING EXAMPLE1
Enter datafile identification
?
KRAUT K5K S/N 52831
DATA STORED
EXAMPLE1 CLOSED
Do you wish to test another device?    (Y/N)
?
N
Do you wish to plot any of the stored data?      (Y/N)
?
N
END OF PROGRAM to measure or plot press RUN key
NEXT EXAMPLE
RETRIEVING DATA
*** IMPEDANCE MEASURE STORE AND PLOT PROGRAM ***
Do you wish to measure (M) or display stored data?  (D)
?
D
Which data file do you wish to access?
?
EXAMPLE1
CONVERTING DATA TO NUMBERS ........
FINDING MAX/MINS ........
MAX    IMPEDANCE Z= 1211.2     PHASE DEG= 85.78                    FREQ=100000
MIN    IMPEDANCE Z= 20.87      PHASE DEG=-86.93                    FREQ= 1000
Do you wish to modify the Y axis (IMPEDANCE Z)scale ?    (Y/N)
?
Y
THE CURRENT Y SCALE VALUES OF IMPEDANCE Z ARE   20.87     1211.2
What minimum Y scale value do you want ?
?
0
THE CURRENT Y SCALE VALUES OF IMPEDANCE Z ARE   0      1211.2
What maximum Y scale value do you want ?
?
1500
Do you wish to modify the Y axis (PHASE DEG)scale to six divisions
This enables phase to be displayed from -90 to +90 Degrees
in 30 Degree steps   (Y/N)
?
Y
THE MIN VALUE OF PHASE DEG IS -86.93   THE MAX VALUE OF PHASE DEG IS 85.78
THE PHASE DEG SCALE RANGE IS -90 TO 90 IN 30 DEGREE STEPS
Do you wish to modify the Y axis (PHASE DEG)scale ?      (Y/N)
?
N
Do you wish to display on VDU (V) or get a hard copy (H)? (V/H)
?
V
After viewing plot press CONT to continue
Do you want a hardcopy ?      (Y/N)
?
```

```
Do you wish to plot any of the stored data?      (Y/N)
?
END OF PROGRAM to measure or plot press RUN key
```

Function	Parameter	Range
Test signal	Level	5mV to 1.1V rms
	Frequency	5Hz to 13.0MHz
Amplitude and phase measurement	$B-A$	0 to $\pm$100dB
	θ	-180 to $+180$ Degrees
	A, B	$+0.8$ to -100dBV
		$+13.8$dBm to -87dBm
	Group Delay	0.1nS to 10S
Impedance measurement	Z, R, X	0.1mΩ to 1MΩ
	Y, G, B	1.0nS to 10S
	L	0.01nH to 1.0KH
	C	0.1fF to 100mF
	D	0.0001 to 10
	Q	0.1 to 1000
	θ	-180 to $+180$ Degrees
Accuracy	Amplitude	0.02 to 0.09dB
	Phase	0.1 to 0.2 Degrees
	Impedance	0.1% of reading

Table I. Brief specifications of analyser.

PLOT SIZE	NUMBER OF PLOTS ACROSS PAGE	Y AXES	AXIS LOCATIONS				PLOT LIMITS				POSITION ON PAGE
			PX MIN	PX MAX	PY MIN	PY MAX	XMIN	XMAX	YMIN	YMAX	
MAXIMUM	1	L and R	7	144	10	90	0	270	5	185	BOTH
SIZE	1	L ONLY	7	145	10	90	0	270	5	185	SIDES
REPORT	1	L and R	10	141	10	90	15	249	5	165	BOTH
SIZE	1	L ONLY	10	145	10	90	15	249	10	165	SIDES
REPORT	2	L and R	10	65	10	90	15	249	10	165	LEFT SIDE
SIZE	2	L and R	80	141	10	90	15	249	10	165	RIGHT SIDE
REPORT	1	L ONLY	10	73	10	90	15	249	10	165	LEFT SIDE
SIZE	2	L ONLY	80	145	10	90	15	249	10	165	RIGHT SIDE

Plot limits are specified by the variables in line 5220 (plot) and 5420 (monitor) with the following format;
5220 LIMIT XMIN,XMAX,YMIN,YMAX
5420 LIMIT XMIN,XMAX,YMIN,YMAX
AXIS LOCATION is specified by values of variables in lines 5270,5280,5290,5300 (plot) and 5470,5480,5490,5500 (monitor)
LABEL SIZE is specified by the value of CSIZE in line 5310 (plot) and 5510 (monitor)

Table 2. Constants for modifying the plot size

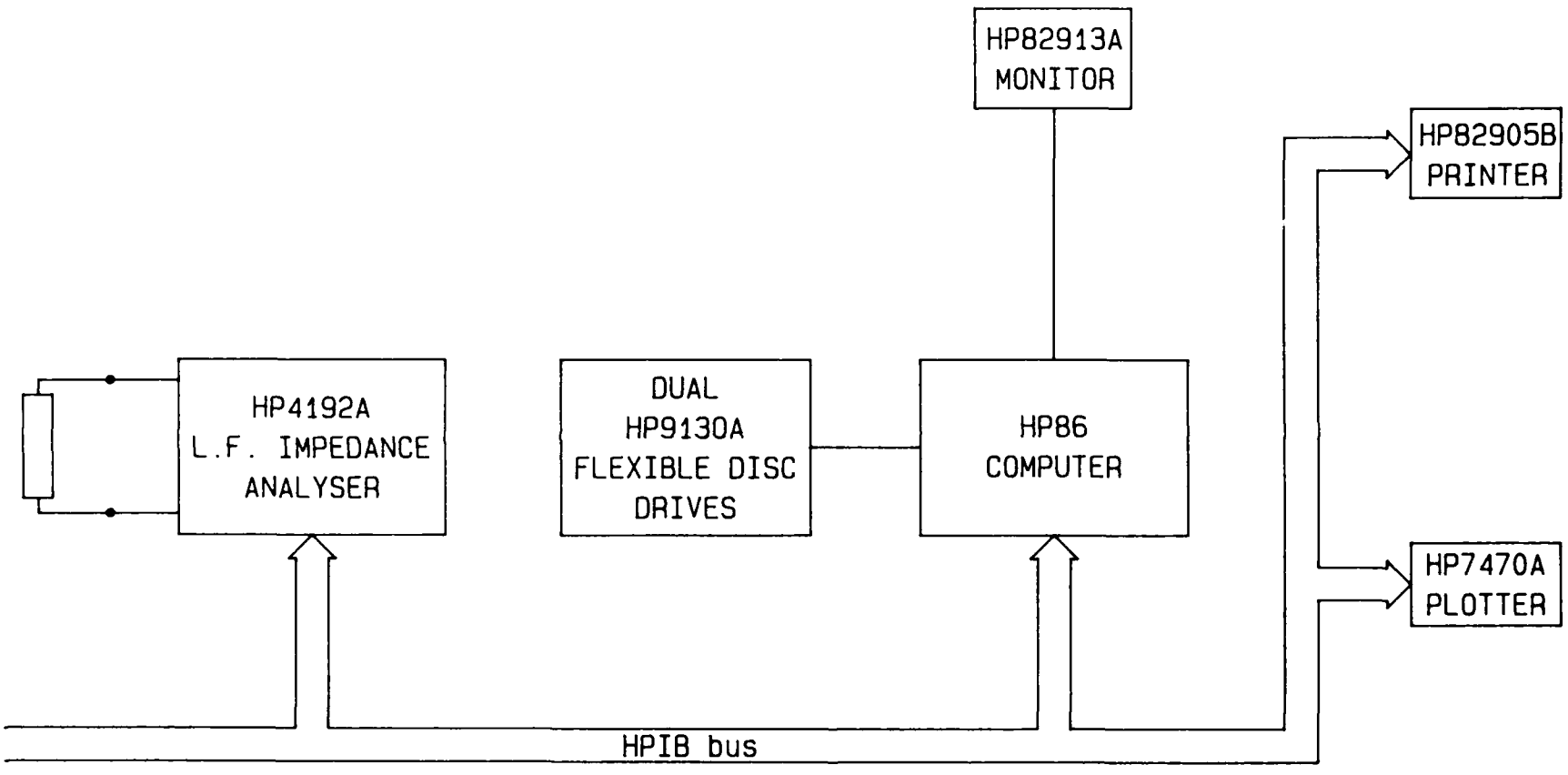


FIG. 1 SYSTEM BLOCK DIAGRAM

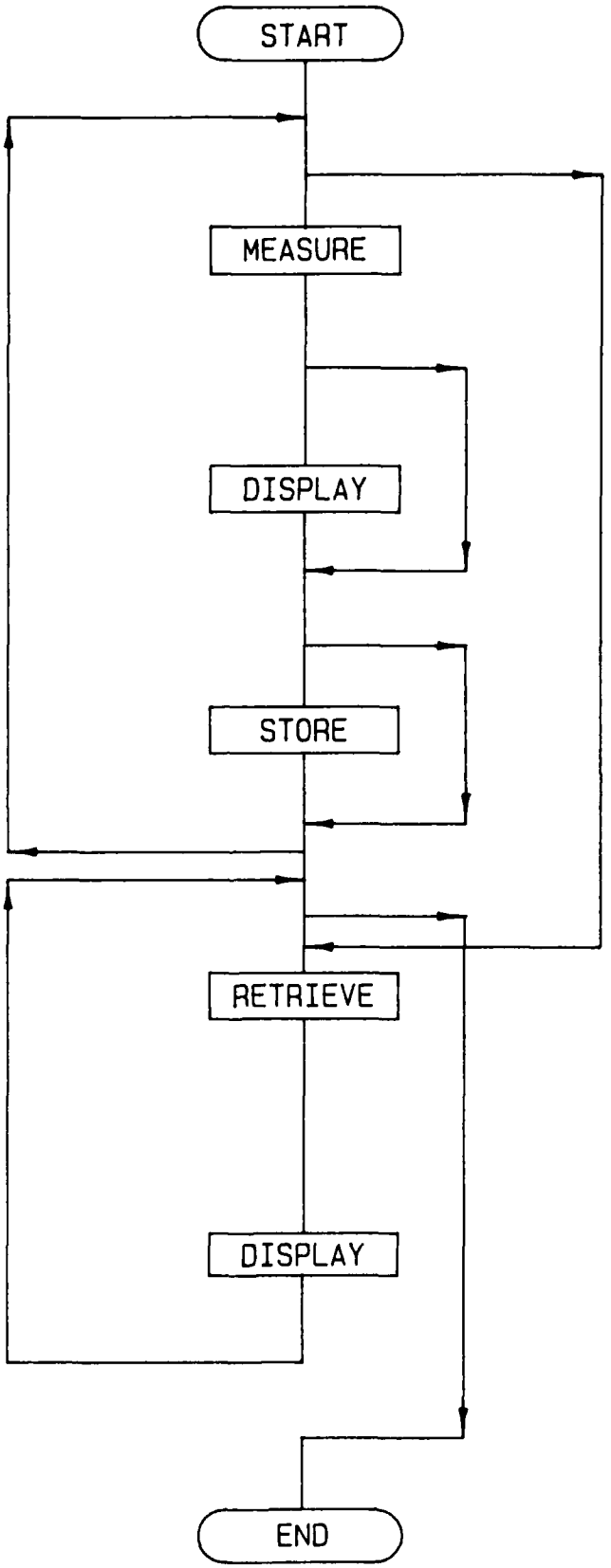
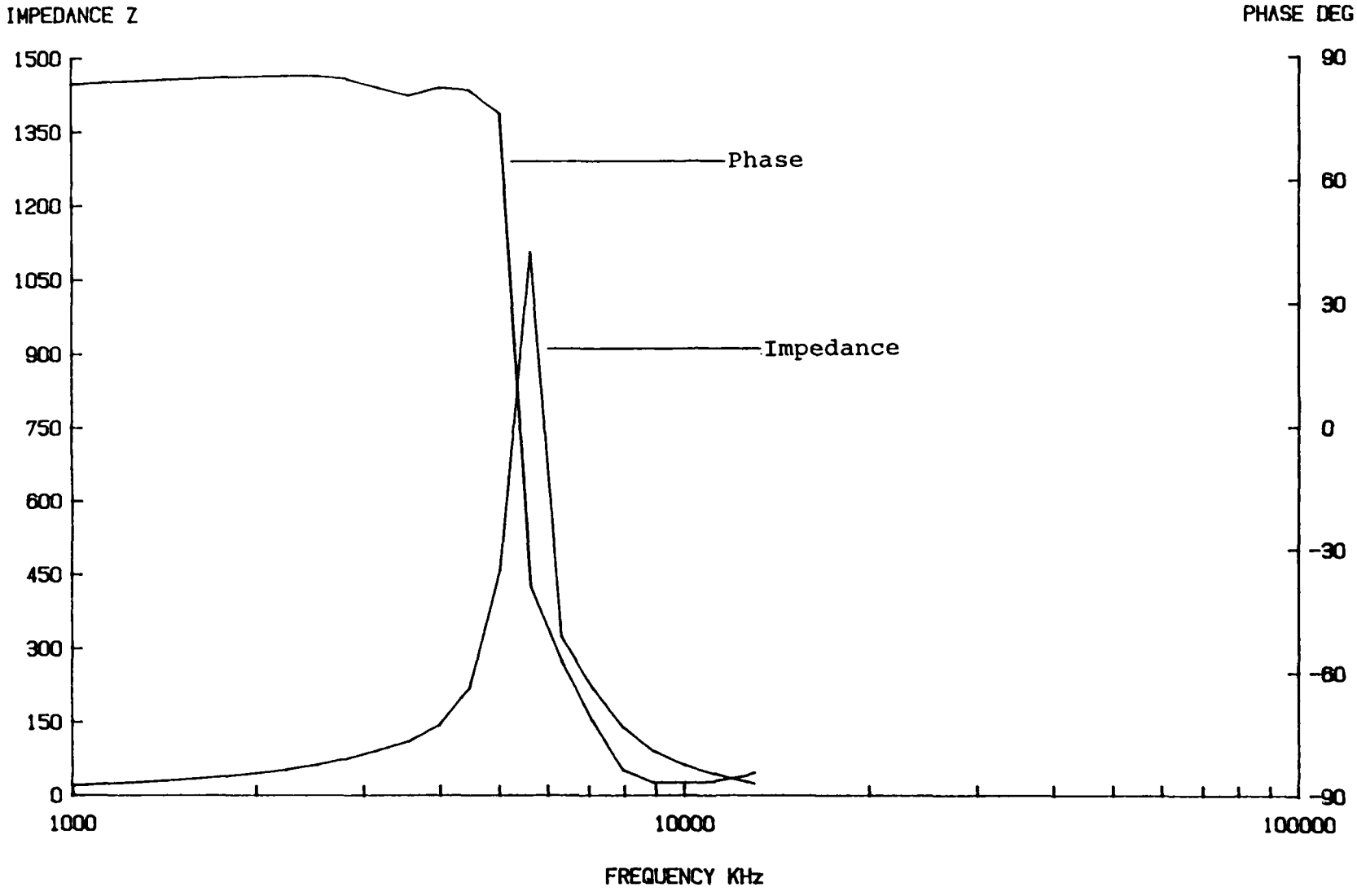


FIG. 2 SOFTWARE BLOCK FLOWCHART



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Operating instructions of a computer controlled impedance measurement system based on Hewlett Packard instrumentation are given. Hardware details, program listings, flowcharts and a practical application are included.

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